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ABSTRACT

This critical review and evaluation of the literature covers the field of computer assisted instruction (CAI) and reading from its inception to the present day. Seventeen research studies are discussed as well as four surveys of previous research in this field. Major issues addressed include the effectiveness of CAI and computer managed instruction as teaching tools; the effectiveness of different CAI modes; the effectiveness of CAI with respect to grade, age, and ability levels; rate of learning or time saved in learning with CAI; the retention of learning once CAI has taken place; and overall student and teacher attitudes towards learning reading skills with the aid of a computer. An appendix includes a coding sheet for the studies reviewed and a chart summarizing the research studies, presenting the reference for each study, date, research design, and methodology (especially the CAI mode and the hardware and software used). Thirty references are listed. (LMM)

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THE FOUNDATION AND DEVELOPMENT OF
COMPUTER ASSISTED INSTRUCTION IN THE FIELD OF READING
FROM ITS INCEPTION TO THE PRESENT

A Master's Project

Presented to

the Faculty of the Graduate Reading Program
Montclair State College

In Partial Fulfillment

of the Requirements for the Degree
Master of Arts in Reading

by

Lea K. Zuberman

December 1983

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ABSTRACT

THE FOUNDATION AND DEVELOPMENT OF COMPUTER ASSISTED INSTRUCTION IN THE FIELD OF READING FROM ITS INCEPTION TO THE PRESENT

Lea K. Zuberger

Computer technology has revolutionized modern civilization since the development of the first completely electronic computer in 1945. Through vast improvements in technology, computers have evolved from clumsy mainframes to minicomputers, to the current state-of-the-art, the microcomputer. Nearly every aspect of modern life has been affected by some type of computer-controlled automation. However, the educational system in the United States, particularly the elementary and secondary schools, has lagged sadly behind business and industry. While schools have been acquiring computer systems and microcomputers to be placed in central facilities or individual classrooms, there has not been an active attempt at implementing computer literacy in public education -- neither for teacher or student.

As a result, students and parents have turned to the consumer marketplace to gain knowledge about computers, whether through educational games, entertainment programs, or by buying some type of home computer. A multitude of computer-related devices and materials has found its way into the home, making it the center for computer literacy at the present time.

Unfortunately, with the schools not taking an active role in making instructional technology readily available to the general student population, an economic inequality will, of necessity, result. Those students whose families have the financial capability to acquire a computer will have a distinct advantage over the disadvantaged students in terms of success in school, advancement through higher education, job opportunities and potential career success.

In reviewing seventeen research studies in the field of CAI, as well as four surveys of existing research, a set of criteria needed to be established. This was done through the formulation of a coding sheet, which listed the different variables that needed to be examined, such as: Type of CAI instruction; Computer system used; Software program used; Funding of the study; Demographics; and Outcome variables.

Each research study was submitted for evaluation through the use of the coding sheet. Once this was accomplished, a grid was constructed to incorporate the variables in order to get an overview of the research. The research studies were also examined for their completeness in reporting methods and findings. An attempt was made to address the issues which have appeared in the literature, as well as several new ones; however, due to a lack of quantified data with respect to the results of the CAI treatment in many of the studies, it was difficult to formulate significant conclusions about many of the issues.

While the general consensus among the studies was overwhelmingly in favor of computer assisted instruction as supplemental to traditional classroom instruction, there was insufficient data reported to formulate valid conclusions on the following issues: The most effective mode of

CAI in teaching reading skills; Effectiveness of CAI and CMI with respect to grade, age, and ability levels; Compression of learning time through the use of CAI; as well as Retention of learning after exposure to CAI.

The trend in the field of CAI and reading research appears to be moving away from the massive, Federally funded university or public school system projects, and towards independent research in specific areas of instruction. Recent research is tending towards the use of the microcomputer to implement a software program which the researcher has either authored himself, or co-authored as part of a team of experts in the field.

One major finding which recurred in this review of the literature was the success of a program which combines aspects of CAI and CMI. This is the program developed by Computer Curriculum Corporation, and marketed by Instructional Systems, Inc. Each time this program was implemented in a research project, the results reported indicated considerable gains in reading achievement.

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Chapter 1

INTRODUCTION AND BACKGROUND

Development of Computer Technology

Human beings have attempted to overcome the limits of their information-processing equipment for thousands of years. A time-line for the development of computer technology as it relates to the classroom might appear as follows:

Paper, pencils and alphabetic writing were developed around 3000 to 4000 years ago. Chalk and blackboards appeared between then and the development of the Gutenberg printing press in 1440. A copy of the Mainz Psalter survives today that was printed with movable type in 1457. Photography was invented in 1839; the phonograph was invented in 1878. Marconi invented the wireless radio in 1895. The DeForest vacuum tube dates from 1907. Television was invented in the 1930's and became widely available in the 1950's....By 1977, 72% of all teachers had television available, even though only 59% used it instructionally. (Singer, Dreher, & Kamil, 1982)

Computers are very recent developments. The first completely electronic computer, ENIAC, was developed at the University of Pennsylvania in 1945. It weighed thirty tons, occupied 3,000 cubic feet of space and used about 18,000 vacuum tubes, which blew out every seven and one-half minutes. The heat generated by the tubes made this and other early computers of little value to education or industry. However, the invention of the transistor in 1947, enabled computer engineers to reduce heat problems and to nearly eliminate tube replacement problems.

The computers which have come to be used in education are digital computers. Their transistors are operated as switches that generally have only two states, on or off (conducting or nonconducting), and are based on the binary number system. This system is what gives the computer its tremendous potential. However, even with this great potential, the

transistorized digital computer did not come into wide use until the development of the integrated circuit at Fairchild Semiconductor in 1949. Integrated circuits are printed or etched onto very small disks or squares of silica.

The development of integrated circuits caused such great price reductions in the cost of computer equipment, that computers became common in colleges, universities, large school systems, government institutions and large corporations. In the early 1970's the most commonly used large computers, known as mainframes in the industry, were the CDC 6400 and 6600 from Control Data Corporation; the IBM 360/40-50-67 and the IBM 370 from International Business Machines; the UNIVAC 1108 from Sperry Univac; the GE 635-645 from General Electric; and the Spectra 70 from Radio Corporation of America. (Mason, Blanchard & Daniel, 1983)

Foundation of Computer Assisted Instruction

While computer technology was rapidly evolving, new developments in the areas of educational psychology, reading theory and data processing languages were becoming integrated into the foundation of the field known as computer assisted instruction.

The first development occurred in 1954 in educational psychology, when B. F. Skinner and several colleagues at Harvard University published a widely acclaimed article on the use of mechanical devices in teaching. (Skinner, 1954) Skinner was the chief proponent of reinforcement theory, which specified that learning takes place most readily in the presence of positive feedback. This aspect of reinforcement theory became incorporated into computer programs intended for instructional use.

During that same year, 1954, a major development in the field of data processing languages resulted in a language called FORTRAN (Formula Translation) which enabled a person who was not a trained computer programmer to communicate instructions to a computer. The implications for computer assisted instruction were great since computers became accessible to educators, whereas they had previously been accessible to only the computer literate elite. Soon after, several computer languages were created to be used specifically for instruction, the best known of which are LOGO and BASIC. Both of these languages are easily used even by elementary students who can use them to program the computer to solve a variety of problems. By 1973, the most popular computer languages were COURSEWRITER II, APL (A Programming Language) and BASIC (Beginner's All-purpose Symbolic Instruction Code). Also very popular were TUTOR and FORTRAN, but these were used less frequently. By 1978, BASIC had become the major author language for instruction. (Mason, Blanchard & Daniel, 1983)

A third major development, occurring in the field of initial reading theory, must be included in the foundation of computer assisted instruction. The idea of a "vocalic center group", published by Hansen and Rogers in 1968, came to influence the early attempts at research in initial reading. The vocalic center group was assumed to be the minimal pronunciation unit rehearsed by the reader in order to build associations between orthography and oral language. From Rogers' description, the vocalic center group appears very much like a syllable and, as such, became the basic decoding unit in the instructional computer design of the initial attempts at reading instruction and research at Stanford University begun in 1964, under the direction of R. C. Atkinson, Patrick Suppes and their colleagues. (Kamil, 1982)

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The mainframe computers that were first used for instructional purposes could operate only one terminal at a time. Project PLATO, at the University of Illinois, started in 1960, with an Illiac I, which served only one terminal. The PDP-1 with which the Stanford project started in 1963, served only six stations, none of which was more than 100 feet away. In time, computer devices called interfaces were developed to enable one computer to be shared by a number of terminals, also known as time-sharing.

The next stage of computer technology produced the minicomputer priced at between \$10,000 and \$30,000. Minicomputers are flexible and programmable, with memory channels for storing information entered by the user. Most frequently used in teaching are the GE 255-235, the IBM 1130, the HP (Hewlett Packard) 2000 and the PDP-8 (Digital Equipment Corporation). Many of these newer minicomputers have more power than the older and larger mainframes, while at the same time costing much less. But even as schools began purchasing minicomputers, the four-bit or four-circuit microprocessor (MPU) was invented by personnel of Intel Corporation in 1971.

The microprocessor contains the most important circuits of a computer and is the size of a postage stamp. By 1972, more than 10,000 transistors could be integrated on a single silicon chip smaller than a postage stamp. In 1976, an eight-bit microprocessor was fabricated on a single chip which contained more than 20,000 transistors. As a result, microprocessor memory size which had previously been specified in K's or thousands of bits (bit=digit-one circuit), is now specified in thousands of bytes (there are 8 bits to a byte). (Mason, Blanchard & Daniel, 1983)

In 1980, approximately 52,000 microcomputers were available for educational use and the number increased by 80 percent in 1981. While most schools still use their

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computers for mathematical instruction, approximately 45 percent of the schools have incorporated the microcomputers in the fields of reading and language arts. (Vabaza, 1983)

Computer Assisted Instruction and Reading

The uses of computers in reading instruction are still increasing and the rate of increase will undoubtedly accelerate throughout the 1980's. A survey of a nationwide sample of public schools by Chambers and Bork (1980), indicated that during 1980-1985, use of computer-assisted instruction is projected to increase from 54 to 74 percent. (Gleason, 1981) As such, microcomputers appear to be the wave of the future. Gleason predicts that in the short run, microcomputers will continue to be improved in their capabilities, while reducing in price, so that educational institutions will acquire them and use them in rapidly growing numbers.

Today, there are two major companies which actively market instructional programs in reading. These are Computer Curriculum Corporation (CCC) and Control Data Corporation (CDC). In order for a school district to gain access to either of these programs, it must purchase the computers, or own or lease the terminals marketed by CCC or CDC.

The computer system sold by CCC has been pre-programmed to use the majority of its memory for storing program information. The hardware must be used exclusively for providing the reading instructional programs which CCC has provided. Historically, the CCC programs can be traced to the principles of the early computer assisted instruction reading programs developed at Stanford University's Institute for Mathematical Studies in Social Sciences by Richard C. Atkinson and his colleagues. (In fact, Patrick Suppes of Stanford is President of the

Company.) These programs involved the concepts of "strands" and "branching" whereby the student is assigned by the computer to the proper level of instruction in a given strand and then is directed as quickly or as gradually as his or her performance warrants to new and more difficult strands. Today CCC markets nine CAI drill and practice reading courses: Basic Reading, Audio Reading 1 and 2, Reading, Grades 3 - 6, Reading 7 - 8, Adult Reading Skills, Reading for Comprehension, Survival Skills, English as a Second Language and Critical Reading Skills.

Reinforcement to students and record-keeping for teachers and administrators are provided by the computer. The teacher may, at any time, call for student and class performance information. The computer will give the following information: 1) Each student's placement in each of the five strands in the program; 2) The amount of time the student has spent on the program; 3) The number of time-outs for each student and 4) Which students used the program on the day of the report. (Mason, 1980)

Control Data Corporation has marketed a reading curriculum which requires the use of hardware for the PLATO program. Especially important in CDC's program is the PLATO terminal, with its touch panel, which allows learners to respond by either typing at the terminal keyboard or by touching the screen in the appropriate place. The PLATO reading curriculum is part of the Basic Skills Learning System, a curriculum designed to enable students to achieve an eighth grade level of competence in reading, mathematics and language skills. A student entering the program will have available on-line tutorials, practice exercises and tests, as well as off-line skill booklets and videotapes. Another feature of PLATO is an on-line dictionary. When the student is working and becomes unsure of a word, the

word "term" is typed along with the unknown word. The definition and picture of this word are then supplied by the computer. Still another aspect of this system includes branching to receive special help and explore references and resources. (Mason, 1980)

Other companies which are at the forefront of computer assisted instruction and reading include Hewlett-Packard, Hazletine Corporation, present developer of TICCIT (Time-Shared Interactive Computer Controlled Information Television), WICAT, Texas Instruments, Apple Computer, Tandy Corporation (Radio Shack) and the Atari Company. A relative newcomer to the field of CAI and reading is the IBM Personal Computer, which was first released in the fall of 1981 and has quickly grown to capture a major portion of the business, home and university markets.

PURPOSE

The purpose of this study is to closely examine the foundation and development of computer assisted instruction (CAI) in the field of reading at all educational levels, in order to gain an insight into the problems that are facing educators today with respect to the acceptance and implementation of computers for instructional use.

A review of the literature will focus on studies that have been done in the field of CAI in reading since its inception in the early 1960's to the present time and will include several reviews of the literature which have already been published.

While computers have been involved in education for the past twenty years and are currently finding their way into all levels of education, it is evident that classroom teachers have not become computer literate as a whole and may have serious doubts about the "invasion" of their territory by the computer. A survey of the studies that have been

done with respect to CAI and reading should serve to acquaint teachers with basic computer concepts, terminology and provide a sense of historical continuity in an area which some may dismiss as being a passing fad. Such a report should also enable reading teachers to formulate a more positive stand towards CAI, as well as pinpoint the trends that are manifesting today. It should also provide some implications and guidelines for the future.

PROBLEM

During the past four decades, computers have become so widespread in every aspect of our daily lives, that some have likened the effects of the computer and communications revolution on modern society to the effects that the technology of the Machine Age had had on the pre-industrial world of the last century.

Computers have evolved dramatically from their beginnings in 1945. Since then, the technology of microprocessors has continued to develop more powerful capabilities and ever-broadening applications. Barriers which had previously blocked the use of computers in various areas have been removed, while improvements in efficiency and quality, as well as greatly refined designs and decreased costs of production, have made computer technology more and more accessible to an ever widening number of people.

Whereas twenty years ago computers were used primarily for payroll and accounting applications, today they are used to solve problems and perform numerous tasks which most people take for granted. For example, in the social sciences, computers are programmed to simulate the cities of tomorrow with the goal of solving problems such as overcrowding, air and water pollution and snarled transportation. In science, they are applied to problems ranging from space travel to malnutrition. In addition,

computers perform industrial tasks such as setting type automatically, monitoring manufacturing machines, providing automatic banking, handling airline reservations, monitoring the progress of thousands of flights, helping engineers design bridges and buildings, as well as watch over critically ill patients, sounding an alarm at the first sign of trouble. (Langer, 0982)

On the consumer level, computer games, word processors, electronic typewriters and microcomputers are widely advertised and can be found in the numerous chain and franchise computer stores that are sweeping the main streets and shopping malls of America.

Computer retail stores such as Computerland, Programs Unlimited, Entre Computers and Radio Shack, are to be found in every major city as well as many smaller towns across the country. Businesses, both large and small, are using microcomputers for payroll, inventory management, accounting, word processing, data storage and information retrieval. In local communities, computer arcades have gained so greatly in popularity that some localities have sought legislation restricting the numbers of arcade shops to be allowed in their town, as well as restricting their hours of business to after-school hours.

In addition, "the microcomputer industry has developed an extensive home computer package with options for word processing, family budgeting, personal investment, business management and more effective record keeping." (Langer, 1982:2) Many of the home computer games include instructional and quasi-instructional programs are being developed for use on the home computer.

What has developed is a curious, yet distressing problem, with respect to computer instruction in the schools. That is, that the computer industry has focused its educational materials on the home market and parents

have then had to take the initiative and push the schools to become involved in the new technology. In turn, the schools see themselves and educators have had to face two serious problems: The lack of adequate instructional software developed for school use and the fact that educators and educational researchers do not tend to be consulted by either the hardware or software manufacturers to set the goals, functions or implementations of new instructional programs. Therefore, these frequently do not reflect the best professional judgments regarding what is known about students and learning, nor do they reflect knowledgeable views of schools and teaching.

As a result, a very serious dilemma has occurred which may have negative implications for the future of education and society. That is, that a major mode of communication and learning has been developed in our society during the past four decades that has revolutionized every aspect of our lives, while the instructional aspects of the new technology are being permitted to passively happen to rather than be actively shaped by professional educators who know about children, schools and learning.

That computer technology has the potential to make a difference in schools is a fact supported by what is known about computers, reading strategies and cognitive theory. However, the sad fact is that "instructional use of computer technology is presently limited in scope, haphazardly organized and administered and accompanied by software that does not reflect current knowledge of the reading process." (Langer, 1982)

If the computer industry and educators do not jointly develop a strategy in order to address the issues of acceptance and implementation of computers for instructional use, innovative learning experiences and computer literacy may be available to only select groups of students--those who perhaps are economically in a position to provide for their own

education through use of the home computer and thereby increasing rather than helping to eliminate the problems of inequality in both school and society.

THEORETICAL FORMULATION

Operational Definitions

The following operational definitions are presented to clarify the meanings of terminology used in the fields of computers as well as computer assisted instruction. As reading teachers are largely unfamiliar with computer "buzz words" and the terms associated with CAI, it is essential that their meanings be made perfectly clear so that a true sense of understanding can result.

1. computer assisted instruction (CAI)-
a term used to describe any instruction in which the material to be learned is presented by equipment under digital computer control and in which the students' responses are relayed to the computer for processing.
2. computer managed instruction (CMI)-
management systems which manipulate data in order to provide the teacher with valuable information about students, as well as free the classroom teacher from tedious record keeping and grading of test papers. In CMI, the teacher uses the computer as a tool to assist in diagnostic, prescriptive and evaluative tasks. CMI does not require that the student learn to operate the computer terminal.
3. drill and practice-
CAI mode of instruction which consists of simple linear programs designed to supplement instruction initiated by a teacher. Drill and practice

programs reinforce skills already learned by presenting problems to solve.

4. tutorial-

CAI mode of instruction is self-contained with machine decisions and branching. Tutorial software introduces new skills - guiding students through an instructional procedure step by step and may include detailed charts, illustrations, an informative audio track and supporting printed materials. (Neuman, 1983)

5. simulation-

CAI mode of instruction in which the learner is projected into a role and is challenged to evaluate information and make decisions. Graphics accompanied by sound effects create nearly realistic animated images and the learner's choices affect the sequence of events.

6. games-

CAI mode of instruction that provides an active source of entertainment while teaching or providing skill practice using competition as the chief motivator.

7. problem-solving-

CAI mode of instruction allowing students to manipulate symbols and words freely, as in word processing.

8. dialogue-

CAI mode of instruction which enables learners to converse with the computer in natural language wherein the student controls the information sequence.

9. strand-

used to identify a basic component skill of initial reading with students moving through

each strand in a roughly linear fashion. (The Stanford Projects, 1967)

10. branching-

progress within strands wherein responses to items are computer analyzed to determine if student needs remediations, if he should proceed to the next item or if he should skip several items ahead.

11. bit-

binary digit which instructs the computer to turn a circuit in the computer on or off, thus determining how the electrical current flows and consequently how the computer "thinks".

12. byte-

a small storage unit that is equal to a letter such as "q", a number such as "2", a mark of punctuation, or a command such as "start or stop". A computer's memory capacity is measured in bytes.

13. cpu-

central processing unit, is the brain of the computer and is made up of one or more silicon wafers or chips (also called microprocessors).

14. memory-

in order to receive and send out instructions and process data, the CPU must have these instructions and data stored in memory. Permanent memory is known as ROM (Read Only Memory). Temporary memory is known as RAM (Random Access Memory).

15. crt-

cathode ray tube, also known as video display terminal.

Research Questions Posed

This paper will present a critical review and evaluation of the literature in the field of computer assisted instruction and reading from its inception to the present day. Seventeen research studies will be discussed as well as four surveys of previous research that had been completed in this field.

It is vital to approach the findings of the various research studies and surveys with a number of questions that need to be addressed by educators as well as other community members. These research questions, if answered will serve to guide the thinking, as well as the policies formulated by school boards around the country towards the use of computers for teaching reading in an instructional setting.

Major questions have been formulated in relation to CAI and reading:

1. What are the most effective modes of CAI with respect to reading achievements?
2. How does the effectiveness of CAI in reading vary with the ability of the student?
3. How does the effectiveness of CAI in reading vary with the grade level of the student?
4. To what extent does the type and expense of computer system used influence the results of CAI instruction?
5. What is the ideal time on task and frequency needed to assure successful learning with CAI?
6. What type of reading skills may best be taught using CAI?
7. Is successful learning with CAI sex-related?
8. Does learning with CAI save time over traditional classroom instruction? If yes, is this

necessarily a benefit?

9. How does CAI in reading affect retention of what has been learned in comparison with traditional instruction?
10. What are the non-academic gains by the student with CAI?
11. What are student and teacher attitudes towards CAI in reading?

Delimitations

There were several criteria used to select the studies that were included in this report. First of all, time limitation was a major determining factor, since instructional use of computers was non-existent prior to 1960 and the first studies of the use of CAI initially really began with the Stanford Project in 1964.

A second criterion used to select studies was to include the major historical developments from 1964 to 1983 both in use of hardware systems as well as software programs in the area of computer assisted instruction and reading. An effort was made to evaluate those studies done at institutions of higher learning and public school systems which would be representative of major development programs in the field. An added criterion was that each study had to focus specifically on CAI and reading.

Finally, the availability of studies was an important delimitation in being included in this review, as some were simply not available as a primary or secondary source.

METHODS AND PROCEDURES

In order to choose a representative sample of research studies and surveys that have been completed in the field of CAI and reading, several steps were taken:

1. An ERIC search was conducted through the Montclair State College Library Reference Department's Bibliographical Retrieval Services, Inc. Some of the guide words used in the search included: Computer-assisted instruction; Reading; Elementary and Secondary Education; Individualized instruction; and feed-back, among others. The result of the ERIC search was a print-out of twelve studies with brief annotated references.

2. The RIE (Resources in Education) Index for July-December, 1982 was consulted for recent studies filed in the ERIC system. These were to be retrieved in microfiche and reviewed.

3. Made use of the References section to Michael L. Kamil's (University of Illinois at Chicago) paper, "Technology and Reading: A Review of Research and Instruction" in tracing several primary and secondary sources.

4. The International Reading Association, Inc.'s 1983 paperback entitled Computer Applications on Reading, second edition, was acquired by first calling the IRA and then placing an order.

5. In order to obtain additional primary sources, a letter was written to IBM Corporation, Thomas J. Watson Research Center, Yorktown Heights, New York, 10598, attention Dr. E. N. Adams, Director, requesting a copy of a 1966 preliminary field test by E. M. Quinn.

6. A letter requesting a copy of "Information Processing Models for Reading Skill Acquisition," technical report, was sent to the National Information Service, Springfield, Virginia 22151.

7. Mr. George Auger, Sales Representative in the East for Instructional Systems, Inc. of Englewood, New Jersey was contacted. A request was made for a marketing package and a copy of evaluative studies done by schools of the Computer Curriculum Corporation's CAI

Programs and Instructional Systems.

8. Dr. Brunner, seminar leader, was consulted for current articles on CAI in the Reading Instruction Journal as well as a text on meta analysis.

Once the information was gathered, two instruments were designed which focused on specific criteria to be used in evaluating the various studies (see Appendix):

- 1) A coding sheet to be used in analyzing each study for substantive and methodological features.
- 2) A grid construct to be used for comparison of the research on a number of variables.

The preliminary coding sheet and grid construct, along with a number of questions, were presented to the graduate seminar for evaluation and modification. After a final format was devised for the coding sheet, each study was individually coded so as to be able to reference the data on similar variables in all the studies at a glance and to be able to spot trends more easily.

A master grid was constructed featuring all of the research studies as well as the significant variables that were designated by the research questions posed.

Finally individual variables were selected and tables constructed to focus on each particular individual variable that may have an effect on this study.

Chapter

CRITICAL REVIEW AND EVALUATION OF THE LITERATURE

Overview

The origins of computer assisted instruction in the field of reading may be traced to the early 1960's when the vast majority of programs were developed on college and university campuses with the aid of funding from the Federal government and grants from private foundations. In addition, many of the early development projects included cooperative efforts between the major computer manufacturers of that period and college and university personnel. These joint efforts resulted in a sharing of ideas such that "instructional program needs led to changes in computer construction and new developments in computer technology led to changes in educational programming." (Mason, Blanchard, and Daniel, 1983)

The majority of studies reviewed involved the use of large computer systems such as mainframes and minicomputers, which dominated the field in the 1960's and '70's. Two studies completed in 1982 were included to represent the current trend in reading research, which is to use the microcomputer. Included in this review of the literature are: (1) Four studies sponsored by Stanford University's Institute for Mathematical Studies in the Social Sciences (Atkinson et al, 1967-73); (2) A preliminary field study completed at IBM's Thomas J. Watson Research Center (Quinn, 1966); An analytical review of PERC (Plato Early

Reading Curriculum) at the University of Illinois' Computer Based Education Laboratory (Yeager, 1971-76); A study of Project COMP for EMR students at the University of Wisconsin's Research and Development Center (Rosenkranz, 1974); The DOVACK study sponsored by Florida State University's Computer Assisted Instruction Center (American Institute for Research, 1971); And a study at Medgar Evers College, City University of New York (Garrity and Barozzo, 1977). Representative of the limited, independent research being conducted in the 1980's are two studies: A study of the effects of computer graphics on learning at Illinois State University (Edyburn, 1982); A study of the use of a microcomputer program on comprehension at Iowa State University at Ames (Henney, 1982).

Many of the early projects developed programs which were later field tested in public and private elementary and secondary schools. These programs were tailored to the school system's instructional needs as well as modified to meet the demands of in-school operations. Included in this review of the literature are: (1) A study conducted of computer assisted instruction in the Chicago Public Schools (Lilman, 1973); A study sponsored by Florida State University and completed in the Wakulla County School System (Elfner, 1974); A study completed in the Ft. Worth, Texas School District (Lysiak, 1976); The IRIS (Individualized Reading Instruction for Students) study conducted in the Rapides Parish School System in Alexandria, Louisiana (Validation Report, 1977); A study of CAI at the Bath Elementary School in Cleveland, Ohio, (Martha Holden Jennings Research Foundation, 1979); And a recent study at the Hudson County Area Vocational-Technical Schools, North Hudson

Center (Instructional Systems, Inc., 1982).

CAI and Research at College and University Centers
in Computer Based Reading Programs

The reading program at Stanford University was developed by Richard C. Atkinson and several colleagues during the years 1964 to 1975, and began with a USOE grant. The original program was intended to be a total curriculum, independent of teachers. However, since no programed curriculum in reading was available for computerized delivery, and no integrated CAI system had been developed and marketed by any one computer manufacturer, Stanford University and IBM worked together between the years 1964 and 1967 to solve both problems. The resulting system, the IBM 1800/1500 consisted of a central computer with disk storage, two proctor stations and an interface to sixteen terminals. These elaborate student terminals consisted of a high speed rearview filmstrip, a typewriter keyboard, a screen, and an audiotape system for delivering messages to students by way of earphones. (Mason, Blanchard, and Daniel, 1983)

Using this computer system, Atkinson and his associates created a "tutorial beginning reading program" in which students responded to video, audio, and rear screen projected displays by pointing the light pencil at the screen. The computer evaluated the student's response and determined the next material to be presented. Using a method called timesharing, sixteen terminals could access the main computer at nearly the same time. (ERIC, ED 155 634)

The first of the Stanford Projects was conducted by Atkinson from 1966 to 1967, when the student terminals and the tutorial reading

program were tried with sixteen first graders reading below grade level. Six kinds of reading tasks were presented to the students by the program using an "intrinsic branching approach": letter discrimination and identification, initial vocabulary, word decoding, syntactic and intonation practice, syntactic and semantic practice, and information processing tasks. Students spent twenty to thirty minutes on CAI daily with post-test results measured by the California Achievement Test and the Hartley Reading Test.

While this original program was considered a success, with reading norm scores for students receiving CAI 1.2 years greater than those of the control groups, there were several criticisms voiced in the literature. Firstly, the entire program was considered to be too expensive to be implemented in the public schools. Secondly, it provided no means of checking by computer the students' ability to produce the sound sequence represented by displayed orthography. Finally, according to Spache (1967), the absence of a teacher as part of the learning process made the program overly mechanized.

As a result, the Stanford group set out to create a low cost CAI reading program to supplement regular classroom instruction. This was achieved by eliminating the expensive CRT and slide projection equipment, and including only the model 33 teletypewriter terminals with audio headsets. This program was designed for Stanford's Digital Equipment Corporation (DEC) PDP-10 computer facility located at the University to communicate with student terminals in participating schools over dedicated telephone lines. This system was used for six school years.

(1969 - 1975) by a total of more than 2,000 students in grades K-3.

The new CAI program in initial reading at Stanford introduced the concept of "stands", or basic component reading skills. When the student had demonstrated sufficient progress in a lower numbered strand, he automatically began receiving instruction in the next higher strand. Any one lesson might involve the presentation of learning material from several strands even though the typical lesson length was set at twelve minutes. Six strands were incorporated in the program:

- Strand I Reading Readiness - learning to use the terminal and following directions.
- Strand II Letter Recognition - copying, recognition, recall of letters.
- Strand III Sight Word Vocabulary - learning seven graded lists.
- Strand IV Spelling Patterns - learning to discriminate, copy and spell word families.
- Strand V Phonics - construction of words from consonants, consonant clusters, and spelling patterns.
- Strand VI Comprehension - categorizing words, filling in blanks, and sentences. (Mason, Blanchard, and Daniel, 1983)

The following three studies were also considered part of the Stanford Projects. First in the literature is Fletcher and Suppes' 1972 descriptive study, "Computer Assisted Instruction in Reading: Grades 4 - 6." In this study, which took place over the course of one year, 162 students were instructed for ten minutes daily, for a total of 150 sessions, using the tutorial program of instruction developed by Computer Curriculum Corporation of Palo Alto, California. Quantitative results of this study are given in terms of grade-by-strand proportion of correct answers and rates of achievement. The researchers observed that the rate of completion of the exercises dropped for students in the upper grades, as there were longer textual passages to complete. The overall conclusion of this study was that a great amount of material could be covered during very short CAI sessions, as short as eight min-

utes each.

A second Stanford Project study was conducted by Fletcher and Atkinson in 1972, and entitled "Evaluation of the Stanford CAI Program in Initial Reading." In this experimental study, fifty pairs of first graders were matched on a number of variables, including reading readiness scores. One child in each pair received CAI in reading and the other child did not. The experimental group taking part in this study received twelve minutes of CAI reading instruction daily for five months, totalling twenty hours during the first grade, and no CAI during the second grade. Both standardized and locally constructed tests were administered at the end of the first grade, including Stanford Achievement Tests and the California Cooperative Primary Reading Test, and again at the end of the second grade. Results of this study indicated that at the end of the first grade, the CAI group had achieved a 5.05 month gain in performance over the control group, while at the end of the second grade, the CAI group showed a 4.9 month lead over the control group. Retention of computerized reading instruction was very high for the CAI group. In addition, gains were greater for boys than for girls. The researchers explained that while girls were far superior to boys on the reading tests used in the evaluation, for the control group, the difference in scores between boys and girls was greater than for the experimental group. Finally, the most significant results were reported for sentence and paragraph comprehension, which could not be anticipated as these areas had hardly been touched by the CAI program.

A third Stanford Project analytical study, conducted by Atkinson, Fletcher, Lindsey, Campbell, and Barr in 1973, entitled "Computer

Assisted Instruction in Initial Reading: Individualized Instruction Based on Optimization Procedures," presents the methodology of strands in combination with "branching" and describes how the computer can prescribe individualized practice for time on task and level of difficulty through constant monitoring. In this study, the researchers present a formula for computing the amount of computer time required for reaching a desired score on a reading achievement test. It also presents a formula for the efficient allocation of a large number of students to a limited number of terminals, for computer time. This study, as well as the previous two Stanford studies, used the drill and practice mode of computer assisted instruction as developed by Computer Curriculum Corporation, and served to supplement the traditional classroom instruction.

The descriptive field study completed at the Thomas J. Watson Research Center at IBM by E.M. Quinn in 1966 used a drill and practice program which was independent of classroom instruction. The subjects in this study were eleven fifth through seventh graders, all reading above grade level, who had been given the Gates Reading Survey for placement purposes. This program was run on an IBM mainframe computer, with IBM terminals and a slide projector. Quinn observed his subjects closely throughout the study and came to the following conclusions:

1. The children worked at their stations without difficulty any amount of time between twenty and thirty minutes.
2. Students' performance generally deteriorated after twenty to

thirty minutes.

3. The children enjoyed the CAI experience.
4. There was some indication that watching the CRT print out words character by character actually helped improve the reading skills of the less able readers. These results were not quantified, however.

In 1960, researchers under the direction of Donald Bitzer of the Coordinated Science Laboratory of the University of Illinois developed a computerized teaching system named Programed Logic for Automatic Teaching Operation, or PLATO. The first PLATO system used machine language, but when the Computer Based Education Research Lab (CERL) was formed and PLATO III begun, several different programming languages were used before TUTOR III was created. TUTOR IV was implemented in 1971, and TUTOR has remained the language of the present PLATO IV program.

Although PLATO was initiated in 1960, the PLATO Early Reading Curriculum (PERC) was not begun until funded by the National Science Foundation in June, 1971. The aims formulated at that time were:

- 1) to create a complete K-5 computer based curriculum in reading;
- 2) to build in the possible use of a variety of instructional modes, thus permitting teachers to maintain their own styles of teaching reading;
- 3) to take full advantage of the advanced devices available to the user of a PLATO IV terminal; and
- 4) to demonstrate the feasibility of the resulting curriculum in a variety of school settings.

In 1977, Robert F. Yeager, the senior author and programmer for

the PERC group, presented a paper to the Annual Meeting of the American Educational Research Association entitled, "Lessons Learned in the Plato Elementary Reading Curriculum Project." In his paper, Yeager reported on some of the successes and failures of PERC, and discussed what the project did; details about the hardware used; how lessons were designed; the two approaches that were taken towards managing the curriculum; how Plato was implemented in the classrooms; and some general observations of a personal nature.

Project PERC was conducted during the years 1971 - 1976 and studied subjects in kindergarten through second grade from twenty-five classrooms throughout Illinois. Towards the end of the study, remedial readers and EMR students were also included. CAI was received three to four times a week for fifteen minutes per session by the experimental groups, although actual time on task was entirely dependent on the classroom teacher, and in some cases did not exist. While PERC lessons were intended to be completed independently at the terminal with no connection to classroom instruction, this goal was never achieved. Yeager indicated that a major conclusion reached by the creators of PERC was that to be effective, CAI had to be integrated into an existing classroom structure. The PERC program was soon moved into a complementary role in the classroom. However, this became a major criticism of PERC and proved to be an expensive lesson to learn. Because PERC had initially attempted to provide independent instruction, lessons were developed in all areas of reading, and as a result, "no area was covered effectively" and "many of the lessons which were produced never belonged on a computer." (Yeager, 1977:13)

Yeager concluded that PERC's major problem was the need for more time and money to do an adequate job, as well as the need of an adequate staff well-versed in both CAI and reading. Yeager reported that very little was done to evaluate the impact of the PLATO computer system in the classroom and stated that, in fact, "PERC really accomplished nothing which would make teachers believe that PERC offered a better way of teaching beginning reading." (Yeager, 1977) Despite this, PERC teachers insisted that Plato had had good effects in their classrooms: (1) it helped more students to read earlier; (2) students learned to follow directions better; (3) students developed better listening skills; and (4) children were helped to be more creative.

Two types of computer applications to reading have been under development at the University of Wisconsin's Research and Development Center: The Wisconsin System for Instructional Management (WIS-SIM); And an on-line program for diagnosing reading difficulties with a PLATO IV terminal. The former, application has been developed more extensively, since it was designed to make use of the well-developed goals and objectives of the Wisconsin Design for Reading Skill Development (WDRSD) and has been under development for a longer period of time. In 1974, Catherine I. Rosenkranz, Evaluation Consultant for the Title VI-B Project COMP (Computerized Operational Material Prescriptions), described an individualized reading instructional program for educable mentally retarded (EMR) children in regular or special classes. Her study was entitled "A Reading Improvement Project for EMR's." The COMP program is designed to correlate with the Wisconsin Design for Reading Skill Development and to utilize a diagnostic reading specialist who

specific reading instructional methods, materials and techniques. The study of Project COMP took place between the years 1971 and 1973, and included a total of 833 students: 160 (EMR); 347 (Disadvantaged); and 326 (Regular K-6). Utilizing the WIS-SIM computer timesharing capability, students received two hours of CAI per week, while teachers received computer printout feedback which identified reading skills that had been mastered and those that had not, as well as materials (with location) for subsequent instruction. Other components of the COMP program were the purchase of instructional materials appropriate for teaching target skills, and the inservice teacher education activities. Rosenkranz reports results that show gains in reading recognition and reading comprehension on the Peabody Individual Achievement Test for the regular students from below average to above national norms. These gains were reported as six months gain per year of CAI. Rosencranz also reported reading gains made with other programs for the EMR students but does not specify these gains nor report them quantitatively, as there were no EMR norms on the PIAT.

The Computer Assisted Instruction Center at Florida State University has conducted several investigations and has completed several projects involving the teaching of reading. The second project of the CAI Center was the implementation of the DOVACK model (1969-1970), in cooperation with an SEA Title III project located at the nearby Monticello, Florida, Elementary School. The DOVACK (Differentiated, Oral, Visual, Aural, Computerized, Kinesthetic) model is a version of the language experience approach. Each day, students dictated a story to their teacher or aide, who recorded it and then redictated it and typed

it on the terminal of the CDC 6400 computer serving the project. Overnight, the computer printed out each new story in the same language which the student had used, but with corrections for spelling. The next day, each student reread the computer printout of his story, studying any new vocabulary words he had used. Every sixth day, the computer created a test which consisted of a random sample of words dictated by the student since the last exam. In addition to his own stories, the student used material devised by the program staff to help achieve the reading objectives of the program. These included a locally prepared DOVACK kit, containing a DOVACK book of stories, a checklist of skills, and a word attacker, a small book of printed words and pictures with a voice recording to match. The word attacker is designed to teach the names and sounds of the letters of the alphabet and the common consonant blends.

The role of the computer in the DOVACK project was primarily that of record-keeper, test producer, and printer, while videotape and field trips were also included. The teacher had access to records stored in the computer, including lists of words dictated by each student, test performance records, total numbers of words dictated per session, and the rate of word acquisition.

The DOVACK study was conducted by the American Institute for Research in 1971, and was comprised of a population of 200 Black students (100 matched pairs) ranked by their scores on standardized tests. There were 57 students in grades five and six, and 43 students in grades one, two, four, and kindergarten. The subjects all read two grades below the national norms. Although quantitative gain results were unavailable at the time of publication, students were described as exhibiting favorable

attitudes towards reading and reading skill acquisition. Teachers as well as parents were also very enthusiastic about the DOVACK project.

In 1977, a preliminary comparative study analyzing CAI and non-CAI Instructional Support Laboratories for Remedial Reading, Writing, and Mathematics courses was conducted at Medgar Evers College, City University of New York by Drs. J. Peter Garrity and Tobin Barrozo.

A combination of Instructional Systems, Inc. hardware of a minicomputer and sixteen terminals, and the Computer Curriculum Corporation's five strand drill and practice and tutorial programs resulted in a CAI gain of 0.52 grade equivalents more than the non-CAI group, at $p < .05$. Evaluation in terms of mean gains was based upon pre- and post-tests of the Stanford Reading Test. Students received CAI twice a week for fifteen weeks, with a total of fifteen hours of instruction. The total population studied included: 34 (CAI) and 213 (non-CAI) students. Two important findings were reported: (1) Data suggests that achievement scores are a function of the time involved in the CAI program, and (2) The greatest impact of CAI was on students pre-testing within the lower achievement ranges.

Independent University Research on CAI and Reading

While studies at the college and university centers in computer based reading programs throughout the 1960's and '70's were generally funded through Federal or State programs, involving major computer systems and large populations of students, the trend for reading research in the 1980's appears to be for independently run research projects conducted at universities, but without Federal financing,

by researchers who author or co-author their own software programs for a specific application and utilize stand-alone microcomputers.

At Illinois State University, David Edyburn studied the "Effects of Computer Graphics on Learning" in 1982 using a descriptive research design for his Master's thesis. Using five stations of Radio Shack TRS-80 Color Computers with nineteen inch color television screens and a program written in BASIC, Edyburn studied a population of 126 seventh grade students, providing the treatment group with graphics enhanced text and the control group with straight text. Using a locally constructed comprehension test for the analysis of results, Edyburn reported no significant difference between groups in comprehension at the .05 level; that graphics had a slightly negative effect on comprehension of the selection; and that a significant difference was found (at the .05 level) between the two groups in the amount of time needed to complete the task. For this, Edyburn faults his software, which entailed the students' watching the graphics being drawn on the screen. In addition, using a pre- and post- instruction attitudinal scale, Edyburn found an overall positive attitude among the students towards CAI.

At Iowa State University at Ames, Maribeth Henney studied the "Development and Use of Microcomputer Reading Programs" in a paper she presented at the Annual Meeting of the Iowa Council of the International Reading Association in 1982. Also without Federal funding, Henney presents an analytical review of her study, conducted at the University with a population of college students, and using an Apple II Plus microcomputer with a software program written by herself and a team of media, education, and programming specialists. Henney's drill and practice and

tutorial program focuses on the comprehension skill of paraphrasing. Although she does not report quantitative results, Henney's recommendations include: (1) a format for integrating her computer program into a total classroom instructional unit; (2) the suggestion that printed materials accompany software programs; and (3) that objectives, readability and interest levels be indicated in all software written for instructional use.

Research Conducted by Public School Systems with
Applications to Reading Instruction

In 1973, G. H. Lilman presented a paper at the annual meeting of the Association for Educational Data Systems entitled "CAI in Chicago," and described a program that involved 12,000 students in grades four to eight, reading below grade level, and working in basic skills (reading, language arts, math) at over 850 terminals. The Computer Curriculum Corporation courseware was implemented in the Chicago study and results were reported to be a gain of at least one month for each month of CAI received in the program. Quantitative results indicated that non-CAI group gains were 5.4 months for ten months of non-CAI classroom instruction, while CAI group gains were nine months improvement for every eight months of instruction. (Mason, Blanchard, and Daniel, 1983)

At Florida State University, Elinor Elfner (1974) studied the "Reading Curriculum Development Project" which was implemented during the years 1970-73 in the Wakulla County School System. Funded in part by an ESEA Title VI grant, this project involved teaching sight vocab-

ulary to forty EMR students in grade one, using an IBM instructional system and an IBM 1800 Central Processing Unit. Thirty tutorial lessons each presenting nine words to be associated with pictures illustrating them were developed in Coursewriter II language and field tested with IBM 1510 terminals (CRT with light pens). The results reported showed that one-third of the EMR students could not do lessons without excessive failure; that additional materials in word attack skills were found necessary; that EMR students need greater emphasis placed on repetition and drill than other students. Significant gains were reported by those EMR students who took extra time to respond to CAI questions, but these were not specified in quantitative terms.

Lysiak (1976) reported on a study on computer assisted instruction in reading and math in the Fort Worth School District during 1975-76. The program, involving students in grades three through seven, qualified under Title I guidelines and was implemented in eight elementary and four middle schools. This CAI project also utilized the drill and practice, and tutorial program developed by Computer Curriculum Corporation. The total population for this study was 2,298 students who received CAI instruction for ten minutes per day for four and one-half months. The control groups received drill and practice classroom instruction in reading and math from a Resource Room teacher. Locally constructed reading and math tests were administered in the Fall and Spring semesters to all subjects in the experimental and control groups. The Iowa Tests of Basic Skills subtests in Vocabulary and Reading were also administered to all third through fifth grade subjects with the following reported results: On the I.T.B.S. tests as well as on locally

constructed tests, third graders who had received CAI achieved greater gains on the Vocabulary and Reading subtests, while fourth graders in the control group achieved greater gains than the CAI students. In the fifth grade, the control groups achieved greater gains on Vocabulary, with no significant differences between the two groups on the Reading subtest. Sixth and seventh graders achieved higher CAI gains on the Vocabulary subtest of the Gates-McGinitie Reading Test than did the Title I control groups receiving Resource Room instruction. Sixth graders also achieved higher end-of-year scores on the I.T.B.S. Vocabulary subtest than did the Title I control group. As a result of these mixed findings, Lysiak states that conclusions are hard to draw. However, it is apparent that CAI was by far a more effective mode of reading instruction than the Title I program.

A 1977 project in the Rapides Parish School District in Alexandria, Louisiana, on "Individualized Reading Instruction for Student Computer-Managed Reading System"(IRIS), provided locally constructed diagnostic tests, computer indexed teaching materials, criterion-referenced tests, and periodic summaries of progress for individual students, classes and schools. An experimental three year study (1972-1975), funded by ESEA Title III, IRIS included 1,000 students in grades three, four, seven and nine scoring below local and national reading norms. The project utilized the UNIVAC 9300 computer at Northwestern State University on a timesharing basis, with Olivetti Programma 101 electronic calculators. The following results were reported: On standardized achievement tests, the CAI group scored higher than the control group in all areas tested; Student attitudes towards reading

instruction improved while teacher attitudes were favorable, especially regarding inservice training.

The Martha Holden Jennings Research Foundation in Cleveland, Ohio, reported the results of a 1978 study of CAI at the Bath Elementary School, funded by ESEA Title IV-C. For one semester, one hundred sixth grade developmental readers received daily CAI for either remediation or enrichment, using the mainframe computer at the University of Akron. Locally constructed diagnostic tests, computer indexed teaching materials, criterion-referenced tests, and periodic progress reports were all part of this experimental study. Preliminary data showed that students gained an average of 2.4 months in reading proficiency during the months they used the computer, and academic gains were reported to be higher for students using CAI. An indirect gain as a by-product of CAI was the training of slow readers' eyes to move quickly along the text presented on the video display terminal.

Instructional Systems, Inc. of Englewood, New Jersey, the marketing arm of Computer Curriculum Corporation, published the results of an Experimental Program at the North Hudson Center of the Hudson County Area Vocational-Technical School, which was implemented in 1981-82. Experimental students in grades ten through twelve received CAI drill and practice in math and reading for two, thirty-five minute periods per week. The results reported were as follows: Before CAI was introduced, students averaged a growth rate of 0.56 years; After CAI was introduced, students averaged a growth rate of 0.76 years. Pre- and post- tests were completed as part of the CCC program, however, no quantitative results were reported.

Summary of Previous Studies on CAI and Reading

Most of the studies done on CAI and reading have involved large computer systems. As such, they are not relevant to the present state of the art where microcomputers are in greater use than during the period when most of these studies were conducted.

Vinsonhaler and Bass (1972) surveyed ten studies of CAI drill and practice programs involving over thirty separate experiments. The results indicated a substantial advantage for CAI as supplementing traditional classroom instruction. Generally, CAI groups showed performance gains in reading of one to eight months over groups receiving only traditional classroom instruction in language arts.

Edwards, Norton, Taylor, Weiss and Dusseldorp (1975) did a similar survey, but did not restrict their research to drill and practice CAI. They studied all four modes of CAI: drill and practice, problem-solving, simulation, and tutorial. Of the six studies cited, none in reading or English showed negative results; Only one showed equal effects of traditional instruction and CAI; five showed the advantage for CAI in which effectiveness was measured by student achievement. As result of these mixed findings, the researchers could not conclude that any one mode of CAI is consistently more effective than other modes.

Jamison, Suppes and Wells (1974) compared the effects of many alternative instructional media. For programmed instruction and CAI, they reported that there were many findings showing no difference in achievement. They did suggest, however, that there could be some savings

in learning time with CAI. Most importantly, however, the researchers found that small amounts of CAI, used as supplements to classroom instruction, led to improvements in achievement, especially for the slower students.

Kulik, Kulik and Cohen (1980) have done a meta-analysis that shows the benefits of CAI at the college level. Though the benefits are small, they are consistent in achievement as a result of CAI. Thus, (Kamil, 1981:258) summarizes the effects of CAI as evidenced in recent research as follows:

1. CAI can be used successfully to assist in attaining specified instructional objectives.
2. There is a substantial savings in time (twenty to forty percent) required for gaining over traditional instruction.
3. Retention is at least as good if not superior to retention following conventional instruction.
4. Students reacted positively to good CAI programs, while rejecting poor ones.

Chapter 3

ANALYSIS OF THE DATA

The purpose of this paper was to examine the foundation and development of computer assisted instruction in the field of reading at all educational levels. Seventeen research studies were reviewed which represent a variety of research designs, treatments, types of systems and programs, as well as document the wide range of research that has taken place since the inception of CAI in the early 1960's.

Nature of the Study Samples

Nearly half of all the research studies cited were sponsored by college and university centers in computer based reading programs. These studies were almost equally divided in research design between experimental, descriptive and analytical, while eighty-five percent were Federally funded, made use of extensive mainframe computer systems, and were specifically aimed at evaluating the success of CAI in reading, rather than CMI. Fifty-seven percent of these studies utilized the software programs developed by Computer Curriculum Corporation of Palo Alto, California, with reported gains in reading achievement.

Nearly one-third of all the studies cited were conducted by public school systems of varying sizes and locations. All of these studies were experimental in design, with subject populations ranging from 1,000 to 12,000 students. Of the public school systems studied,

Table 1
Nature of the Study Samples

Research Sponsor	#Studies	Funding		Computer System			Type of System	
		Federal	Other	Micro	Mainfr	Mini	CAI	CMI
College and University Centers	7	6	1		6	1	6	1
Public School Systems	5	3	2		2	3	4	1
Computer Manufacturers	1	0	1		1		1	0
Private Foundation	2	2			2		0	2
Independent Research	2	0	2	2			2	0
Total	17	11	6	2	11	4	13	4

Table 2
Research Design

Research Sponsor	# Studies	Experimental	Descriptive	Analytical
College and University Centers	7	3	2	2
Public School Systems	5	5	0	0
Computer Manufacturers	1	1	0	0
Private Foundations	2	2	0	0
Independent Research	2	0	1	1
Total	17	11	3	3

Table 3

Software Programs Used

Research Sponsor	# Studies	CCC*	Coursewriter I or II	PLATO IV	Researcher Authored	Local
College and Uni- versity Centers	7	4	1	1	0	1
Public School Systems	5	3	0	0	0	0
Computer Manu- facturers	1	0	1	0	0	0
Private Foundations	2	0	0	0	2	0
Independent Research	2	0	0	0	2	0
Total	17	7	2	1	2	3

sixty percent were Federally funded, eighty percent were studies of CAI specifically, rather than CMI, while they were almost equally divided between use of mainframe and minicomputer-based systems. Sixty percent of these studies utilized the software program developed by Computer Curriculum Corporation, accompanied by the hardware package marketed by Instructional Systems, Inc.

The remaining studies (thirty percent) were sponsored by either a major computer manufacturer, such as IBM, private research foundations, or represented independent researchers. This was the most diversified group of studies with respect to research design, as sixty percent were experimental, and twenty percent were either descriptive or analytical. A major distinction between this group of studies and those previously discussed was that these studies were almost equally divided between CAI and CMI in reading. However, there was similarity on other factors: Twenty percent were Federally funded; They were almost equally divided between mainframe and microcomputer-based systems. With respect to software programs used, this group was also the most diversified, with twenty percent using Coursewriter I, the early IBM computer language, forty percent using a program that was locally developed, and forty percent using a program that was either completely or partially prepared by the researcher himself.

Effectiveness of CAI in Reading According to Mode of Instruction

From the evidence available from the seventeen studies reviewed, it is clear that the overall results of CAI are positive in any mode

of instruction, with a number of studies reporting a gain of as much as one month growth in reading achievement for each month of CAI in reading. However, due to a large number of studies which either do not quantify their results or did not report them in their findings, it is not possible to draw any definite conclusions as to the consistent effectiveness of any one mode of CAI. However, from the standpoint of usage, the drill and practice mode appears to be favored among the research studies reviewed.

Effectiveness of CAI According to Grade and Ability Level

Of the thirteen studies devoted to CAI research in reading, only six reported quantified results. Four of these reported positive gains ranging from 5.05 months per five months of CAI treatment, to 1.2 years per one year of CAI treatment. All four studies reported using standardized as well as locally constructed tests as the basis for their findings. Edyburn's (1982) study reflects no significant gain in comprehension when graphics are added to the text, while Lysiak (1976) reported mixed results.

Compression of Learning Time with CAI

Several studies have demonstrated that CAI in reading can result in reading achievement gains, ranging in effectiveness from a one-to-one, to a two-to-one ratio of CAI treatment to non-CAI control. Due to the fact that a great amount of material can be covered during a short period of time with CAI, students' rate of learning appears to accelerate over the rate at which they learn with traditional classroom instruction. The ability of students to learn faster with CAI contributes

to the overall effectiveness of CAI, as long as learning is retained.

Most Effective Time On Task

Time on task varied with each study, ranging from ten minutes of CAI per day to a maximum of thirty-five to forty minutes of CAI per day. Frequency of instruction ranged from daily CAI exposure to three to four times per week. An average of the various times on task reported by a total of the studies was found to be twenty-three minutes of CAI as the most effective amount of time spent in order to achieve reading gains.

Retention

Only one study addressed the issue of retention of learning with CAI versus traditional teaching, and that was Fletcher and Atkinson's (1972) study, which revealed a high level of retention of reading skills learned after one full year without any CAI.

Effectiveness of CMI According to Grade and Ability Levels

Although positive results were reported by all four CMI-related studies, only two of these studies reported quantified reading gains. Of these two studies, Rosenkranz (1974) reported gains of six months per year of instruction utilizing a computer managed system, while the Martha Holden Jennings Research Foundation (1978) reported gains of 2.4 months per two months of instruction. Gains were reported for both remedial and development readers, although EMR students' gains were not quantified due to a lack of norms on the standardized tests administered.

Critical Age Levels for Maximum Learning via CAI

Reading achievement growth has been reported by several of the studies reviewed in this paper for all ages and grade levels, from beginning readers in kindergarten all the way up to college students. For example, Atkinson (1967) reported a 1.2 year gain in reading achievement while the North Hudson Center study (1982) reported gains of 0.76 years after CAI treatment. As a result, learning does not seem to be specifically related to a critical age or grade level for maximum gain. Rather, it appears to depend more on the time spent on task with CAI or CMI. Repetition, consistency and reinforcement seem to be the key elements in achieving reading gains.

Reading Skills Best Taught with CAI

According to the CAI studies cited in this paper, the majority of the programs present initial reading skills such as decoding, word attack, vocabulary and syntax as major components of CAI. However, at least twelve out of the seventeen studies reviewed also include some form of comprehension skills in their CAI program, regardless of whether it is the simple level of literal comprehension using the drill and practice mode, or the more complex inferential/interpretive comprehension using the tutorial or problem-solving modes of CAI.

Student and Teacher Attitudes Towards CAI

Several of the studies (Yeager, DOVACK, Garrity and Barrozo, Rapides Parish, Edyburn, and IRIS) address the issue of student and teacher attitudes towards the instructional use of the computer.

In all of these studies, both students and teachers appear to favor the use of the computer as supplemental to traditional classroom instruction. Teachers' attitudes towards CAI in reading appeared to improve markedly when provided with a strong supportive program of inservice training. (DOVAK, and Rapides Parish)

Chapter 4

FINDINGS AND INTERPRETATIONS

Several major issues were raised in light of the findings reported in the research studies reviewed in this paper. These included the effectiveness of CAI and CMI as teaching tools; the effectiveness of different modes of CAI; the effectiveness of CAI with respect to grade, age, and ability levels; the rate of learning with CAI, or time saved in learning with CAI; the retention of learning once CAI has taken place; and overall student and teacher attitudes towards learning reading skills with the aid of a computer.

A major obstacle to drawing conclusions regarding the major issues raised was the lack of quantified data in a large number of the studies reviewed. Thirteen studies which were analyzed for the effectiveness of CAI according to mode produced only six studies which reported quantified results of the CAI treatment groups. From such a small number of studies reporting results, it was not possible to draw a valid conclusion as to the most effective CAI mode for learning reading skills. It may be noted, however, that drill and practice as well as the tutorial mode appear to be the most prevalent among the studies reviewed in this paper.

Unreported gain scores also proved to be a detriment to drawing conclusions as to the effectiveness of CAI and CMI according to grade and ability levels. However, it was noted that of the thirteen CAI

studies cited, seven did report significant gain scores and of these, five treated remedial students, one treated developmental students, and one study did not report an ability level. The conclusion that remedial students were able to gain the most from CAI in reading was reported in the study conducted at Medgar Evers College, in which students pre-tested in the lower achievement ranges produced the greatest gains. Six of the CAI studies simply did not report any results in quantified form, although Yeager outlines certain gains that were made in learning reading processing skills, while Henney makes recommendations for teacher constructed software, and Quinn observes some gains in reading skills.

As to the CMI studies reviewed, only two reported quantified gains, and while all four studies described positive gains as a result of their CMI programs with remedial, EMR, and developmental students at grade levels K - 9, the missing data on post-testing evaluations in half of these studies tends to weaken any conclusions that might be drawn.

It is interesting to note that the degree of sophistication of the computer systems used for CAI or CMI in reading did not correlate with positive gains in achievement. A good example of this finding is Fletcher and Atkinson's (1972) study, which reveals the success of the revised Stanford Project program for CAI using the PDP-10 computer system with only a teletypewriter and screen. This was also demonstrated in Yeager(1977) analysis of the PERC Project, in which the sophisticated PLATO IV system did not lead to dramatically successful gain scores in reading.

/the positive impact of this finding should be felt widely by the educational community, since the cost factor of a simple and small

computer system would be greatly reduced, and therefore affordable by a wider range of educational systems and institutions.

The very visible positive results of CAI in reading produced by the pre-packaged program produced by Computer Curriculum Corporation and marketed by Instructional Systems, Inc. must be noted, as seven of the eleven studies reviewed made use of this system of CAI with reportedly great success. Reading achievement gain scores were reported for remedial students only, however.

The finding that remedial students seem to achieve greater gains in reading achievement through CAI and that boys seem to benefit more than girls from CAI in reading should be an encouragement for university reading clinics to initiate the use of computerized instruction, especially as there are increasing numbers of students who enter college with low skills in reading and language arts. School systems would also benefit greatly with either a pre-packaged computerized system, or a form of computer managed instruction, where reading teachers and specialists may use the central computer facility for diagnostic, prescriptive, and evaluative tasks.

APPENDIX

SUBSTANTIVE FEATURES unique to this analysis

I. INSTRUCTION

- A. Reading Skill Taught: ☐ Letter Identification
☐ Initial Vocabulary (Sight Word Recog.)
☐ Word Decoding (Spelling Patterns)
☐ Syntactic and Intonation Practice
☐ Syntactic and Semantic Practice (Word and Sentence Comprehension)
☐ Interpretive Comprehension
☐ Work Study (Use of Sources)
- B. Duration of Instruction ☐ Hours ☐ Weeks ☐ Months
- C. Time on Task ☐ Minutes ☐ Times per Week
- D. CAI Mode used ☐ Drill and Practice
☐ Tutorial
☐ Simulation and Games
☐ Problem Solving
- E. Supplemental vs. Integral Instruction
☐ CAI Supplemental to Classroom/Lab instruction
☐ CAI constitutes entire teaching of subject
- F. Type of Motivational Feedback
☐ Visual/Graphic
☐ Auditory, Critical
☐ Auditory, Positive, Exclamatory
☐ Mixed
- G. Type of Hardware used ☐ Teletype Model 33 terminal, no audio
☐ Same, with audio and light pen
☐ Dictaphone, Tape Recorder
☐ CRT terminal with audio
☐ Same, without audio
☐ Minicomputer
☐ Microcomputer
- H. Cost effectiveness
- I. Teacher Reports ☐ Frequency
☐ Degree of individualization
☐ Prescriptive

II. DEMOGRAPHICS

- A. Sample population primarily ☐ Rural ☐ Urban ☐ Suburban ☐ Univ.
- B. Pupil Ability ☐ Remedial ☐ Developmental ☐ Handicapped
- C. Average age ☐
- D. School Level ☐ Elementary ☐ Middle School
☐ Secondary

III. OUTCOME VARIABLE

- A. Type: ☐ Standardized Achievement Test
☐ Ad Hoc Achievement Test
☐ Retention
☐ Pupil Attitude
☐ Teacher Attitude or satisfaction
☐ Teaching Behavior
☐ Teacher/Pupil interaction

- B. Follow-up Time: ☐ weeks from the end of instruction to the

I. IDENTIFICATION

A. Authors:

C. Year:

B. Title:

D. Source of Data:

52

II. CONDITIONS for STUDY

A. Study Setting ☐ Regular Classroom ☐ Lab ☐ Experimental

B. Method of Assignment of study sample to groups:
☐ Random ☐ Uncontrolled ☐ Matched

C. Assignment of Instructors to group:
☐ Random ☐ Uncontrolled ☐ Matched

D. Percent Attrition of sample

III. OUTCOME VARIABLE

A. Quantification of Outcome:

☐ Gain Scores (simple)
☐ Residualized Gain Scores
☐ Uncorrected dependent variable

B. Congruence of CAI Instruction and Outcome measure:

☐ High ☐ Average ☐ Low

C. Quantification of Outcome Variable:

Standardized Mean Difference ☐
 (Measurement of Experimental Effect Size)

RESEARCH ON COMPUTER-ASSISTED INSTRUCTION and READING

REFERENCE
for STUDY

YEAR(S)
of STUDY

RESEARCH
DESIGN

SUBJECTS
n= size
age, IQ,
sex, grade,
ability level

DEMOGRAPHICS

METHODOLOGY
CAI Mode,
Duration of
treatment,
Hardware/
Software used

EVALUATION
Standardized
Tests; pre-
and post tests

RESULTS
Gain scores,
Standardized
mean diff.
F/U time,
Significance

RECOMMENDA
TION

REFERENCE FOR

STUDY	YEAR(S)	RESEARCH DESIGN	METHODOLOGY
The Stanford Projects: Atkinson, Richard C., et al. Stanford Univ., Palo Alto, Ca. 1966-67	1964-1975	Experimental	IBM 1500:1964-68 picture projector, CRT, Audio system; light pen, keyboard, Audio system for recording. Tutorial Mode.
Fletcher and Suppes, 1972	1970	Experimental	Honeywell 1648 Fortran System: Model 33 tele- typewriters, ASCII keyboards. Drill & Practice Mode.
Atkinson, Fletcher, Lindsay, Campbell and Barr 1973		Experimental	PDP-10 (DEC) computer on IMSSS system; Model 33 TTY, earphones, audio amplifier. Drill and Practice Mode.
American Institutes for Research in the Behavioral Sciences; Florida State Univ., 1970	1969-1970	Descriptive	Florida State U. computer, unspec. Dictaphone belts, Tape recorders. Differentiated, Oral, Visual, Aural, Computerized, Kinesthetic Mode(DOVACK)
Elfner, Elinor Wakulla County Board of Public Instruction, 1973	1970-1973	Descriptive	Unspecified computer. Programs developed for EMR students. Drill and Practice Mode.
Rosenkranz, Catherine I. Cooperative Educational Service Agency 3, Wis- consin State Dept. of Public Instruction- Div. for Handicapped Children., 1974	1972-74	Descriptive	Unspecified computer. Project COMP-- Computerized, Operational, Materials Prescription. Individualized program correlates with Wisconsin Design for Reading (WDR).

Office of Education (DHEW) 1972-75 Rapides Parish School Board, Alexandria, La. 1975 Validation report.	Experimental	Unspecified computer. Individualized Reading Instruction for Students (IRIS) Mode unspec.
Medgar Evers College- C.U.N.Y., 1976 Dr. Garity, Instruc- tional Systems, Inc. and Dr. Barrozo, Dir. of CAI	Experimental	Minicomputer from Instructional Sys.Inc. 16 CRT terminals, mini- printer. Software by Computer Curriculum Corp., Palo Alto, Ca. Tutorial Mode.
Lysiak, Fae, et al. Fort Worth Independent School District, 1976 Texas Dept. of Eval. and Research.	1975-76 Experimental	Minicomputer and CRT terminals;unspecified. Software by Computer Curriculum Corp.(CCC) Drill and practice Mode.
Yeager, Robert F. Paper presented at American Educational Research Assoc., 1977, University of Illinois	1971-1976 Analytical	PLATO READING CURRICULUM program by Control Data Corp. Plato terminal with touch panel-learner responds by typing on keyboard or touching screen.Off-line skill booklets and videotapes. "PERC" -- Plato Elementary Reading Curric. Drill and Practice Mode.
Hudson County Area Voc- 1981-82 Tech Schools, North Hudson Center. Instructional Systems, Inc. Englewood, N.J.	Experimental	* CCC-17 Instruc. minicomputer system and CRT terminals.Earphones for Audio system.Software by Computer Curriculum Corp., Palo Alto, Ca.
South Country Elementary School, Baysboro, NY 1981-82		Same as above
Board of Cooperative 2980-81 Educational Services (BOCES) Binghamton, NY		Multi-Occupational Learning Experience for EMR students. Same as above.
Katherine A. Deasy School 1981-82 Glen Cove, NY		Same as *

Edyburn, Dave Lee.
Illinois State Univ.
1982 MS Thesis

1982
Descriptive

TRS-80 Radio Shack
Color Microcomputer, 19" color TV.
Program in Basic,
with and without
Graphics. Students press
Enter key only.
Problem-solving mode.

Honney, Maribeth.
Iowa State Univ. at
Ames. 1982 Paper
presented at Annual Mts.
of Iowa Council of the IRA

1982
Analytical

Apple II Plus Microcomputer.
Customized software on
Comprehension Skill of
Paraphrasing. Tutorial
Mode.

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